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ABSTRACT

This report summarizes and synthesizes current research on the effects of using word processors on students' writing performance. The report examines cognitive models of the writing process, issues in the assessment of writing performance, and research on instruction in keyboarding. The work was carried out as part of a course requirement by graduate students in educational psychology at the University of Calgary. One figure is included, and 147 references are appended. (MS)

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Word Processing and Writing: A Critical Synthesis

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Executive Summary

This report attempts to summarize and synthesize the research on the effects of using word processors on students' writing performance. In doing so, the authors have given little attention to the large volume of anecdotal reports of the effects of word processing on writing or the teaching of writing. We do not wish to discount these reports; they have established that many teachers and writers perceive great value in using word processors as an aid to writing. We have taken our task as testing whether those perceptions are supported by research that examines the question more systematically and more specifically. To accomplish this task, we found it necessary to examine cognitive models of the writing process, issues in the assessment of writing performance, and research on instruction in keyboarding. The work was carried out as part of a course requirement by graduate students in educational psychology at the University of Calgary and was partially funded by a contract awarded to the university's Education Technology Unit by the Calgary Board of Education.

Renewed interest in the teaching of writing has been the result of a fortuitous coincidence involving "the process approach" to writing instruction (e.g., Graves, 1983) and the availability of a new writing tool that appears particularly well-suited to that approach, the word processor. Researchers in cognitive psychology have attempted to describe in detail the cognitive processes people use when writing. We have found it useful to represent this work in terms of four interrelated activities:

a.) Generating - locating or producing information for the writing task.

b.) Organizing - relating individual pieces of information to one another in a structured whole.

c.) Composing - translating the organized information into the linear sequential structure of text, and

d.) Revising - altering the products of any of the preceding activities.

While computers might aid writers in any of these activities, word processors have been particularly promoted for their potential to improve revision. Software to support the other activities has only begun to be available.

Most of the research on the effects of word processing has relied on "holistic" evaluation -- structured ratings by several trained readers. Although these studies generally have not found any overall improvement in the quality of students' writing when they use word processors, one carefully controlled study did find a difference when writing time was held constant for all students. This suggests that in untimed circumstances students using word processors might achieve the same quality product in a shorter period of time.

While the overall quality of word-processed writing may not be better, the research does indicate that students who write with word processors do more revision of their writing than do students who write with other tools. The failure of these revisions to produce markedly better final products is likely to be the result of the nature of the revisions made (minor editorial changes) and the absence of instruction concerning the nature and purposes of revision.

If word processors are to become an important writing tool in schools, it will be increasingly necessary to address the question of keyboarding instruction. There are surprisingly strong feelings on several sides of this question, but the literature indicates that students can acquire keyboarding skills at an early age and that success in teaching the skills can be achieved by either elementary teachers or business education teachers with or without the aid of computer-based typing tutorials. It is also clear that there is little reason to teach keyboarding unless students will have regular, frequent needs to use word processing in their school work.

Although systematic research regarding affective responses to keyboards/word processors is scarce, most researchers report that students enjoy using keyboards and word processors.

It is important to note some significant limitations in the available research. Most of the research on the effects of word processing has been conducted with university students as subjects. Its applicability for school age populations is open to question. The use of holistic evaluation, while defensible in terms of scorer reliability and face validity, means that only very large differences in the quality of written work would show up in the research. More refined measures have had limited use. Much of the literature on keyboarding has been produced by business education teachers, some of whom frankly acknowledge the stake their profession has in promoting systematic skill-based instruction.

WORD PROCESSING AND WRITING: A CRITICAL SYNTHESIS

Cognitive Aspects

Models

Writing is a complex cognitive task. In evaluating tools and procedures for supporting such a task, it is useful to have a specific cognitive model that describes the processes involved.

Cognitive scientists who study writing have not yet formulated a single, universally accepted model of the writing process. The work of each group of investigators represents a perspective on writing appropriate for their specific research. Still, the various perspectives have much in common. This section will explore several cognitive models of the writing process and discuss some issues arising from the models.

Kintsch and van Dijk (1978) have developed a cognitive model of writing that assumes that writers begin with a specific task. Within the context of this task, the writing process consists of two kinds of operations:
a) production operations, which are used to retrieve information and
b) transformation operations, which are used to reorder the information, add explanations of the structure, make lexical substitutions, and present different perspectives on the information. In addition, writers may add "meta content" which consists of comments and opinions about the information and the way it is structured.

Hayes and Flower (1980) presented a cognitive model of writing that involves three general activities: planning, translating, and reviewing. Planning consists of three sub-activities which are used iteratively (plan, generate, and revise one paragraph; plan, generate, and revise the next

paragraph, etc.) and recursively (i.e., revising a paragraph plan may involve generating and revising some new material to be added to the paragraph).

Collins and Gentner (1980) view writing "as a process of generating and editing text within a variety of constraints ...." The constraints can be grouped into three sources -- structure (good sentence, paragraph, and text form), content (what ideas to include and how they are related), and purpose (the goals of the writer and a model of the reader).

Neuwirth, Kaufer, Chimera, and Gillespie (1987) suggest that expository writing involves the transformation of a network representation of ideas into a linear document. Their model identifies four activities central to the writing process: acquiring knowledge, exploring different perspectives, developing and identifying structure, and selecting and arranging content.

Smith, Weiss, and Ferguson (1987) base their model of the writing process on the concept of a cognitive mode which uses specific cognitive processes to transform the product of a previous mode according to a set of rules. The four modes inherent in their model are prewriting, organizing, writing, editing.

Framework

Although the details of these models differ, they have much in common. All suggest that written text is the result of the application of a number of distinct activities which interact in complex, interconnected ways. There is enough similarity between the activities proposed by the models that they can all be considered to represent one general framework that resembles the model presented by Smith et al., (1987). We will use this framework not only to

describe the various cognitive models in this section also but as a continuing, unifying element throughout the paper. We are not claiming that this model is unique or definitive, only that it seems to capture the common features of the other models, perhaps due to its later development.

The framework we will use (see figure 1) describes writing as consisting of four interrelated activities -- generating, organizing, composing, and revising.

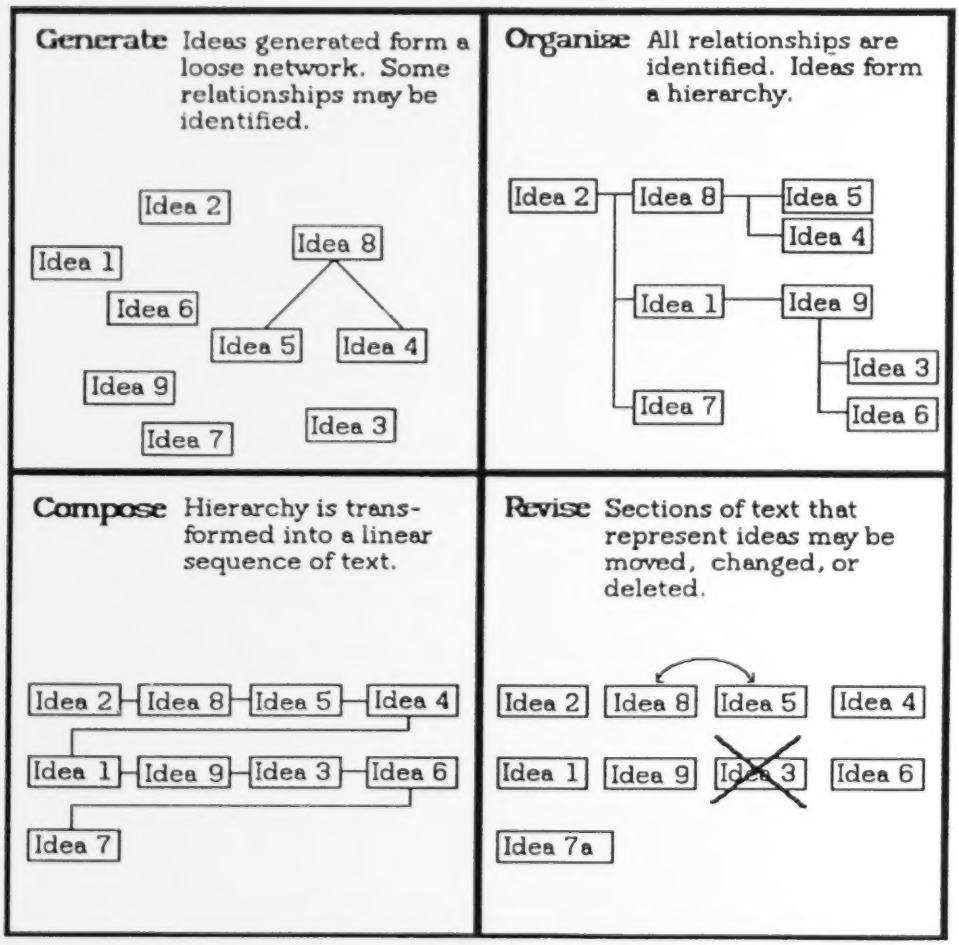

Figure 1. Structure of Ideas Associated with each Writing Activity.

Generating

The initial writing activity consists of accumulating pieces of information from long term memory (LTM) and external sources like books or conversations.

However, the information accumulated in this process is more than just content. Instead, some of the pieces of information accumulated represent relationships between other pieces. At this point, it is important to avoid consideration of the overall structure of the document so that the writer is not constrained in the discovery of new relationships. In addition, the writer may engage in selection since some information found or remembered may be inappropriate for the writer's goals. It is important, however, that the writer not engage in too much evaluation at this point. The cognitive complexity associated with evaluating the existing material may inhibit generating new information. Moreover, since the writer is unlikely to have committed to a specific writing plan at this point, there is no clear basis for evaluation.

The product of the generation process is often a tangible representation of the pieces of information (e.g., notes). To the extent that this representation of the information can be considered to have structure, it can best be characterized as a loose network of linked pieces of information. This loose structure allows the writer to easily incorporate new ideas as they are generated. It also provides maximum freedom to group, manipulate, and alter ideas.

Organizing

Writers will rarely, if ever, include all of the information they generate about the topic at hand. Instead they select the most useful information and organize it into a 'writing plan.' Ordinarily, a writing plan has a structure which is either linear, hierarchical, or some combination of these. Fitting information into the plan involves identifying subordinate and superordinate relationships between items; perceiving comparative levels of abstraction; and determining sequence, proportion and balance.

Any given organization of the pieces of information can be considered to represent one perspective on that information. The quality of writing has been said to depend directly on the extent to which the writer has examined the information from different perspectives (Neuwirth et al., 1987). The effort invested in achieving a physical representation of even one organization of the information provides a disincentive to consider other organizations:

> "One of the most damaging habits for a novice writer to have is that of confusing idea manipulation with text manipulation so that text structure constraints enter into the process of writing at an early stage before the ideas are ready" (Collins and Gentner, 1980).

There is some reason to believe that the activity of organizing is particularly important in teaching children to write. Even though children have a much smaller body of 'world knowledge' to deal with, their "main problem with content is in getting access to, and giving order to, the knowledge they have." (Bereiter and Scardamalia, 1982). This suggests that the

quality of children's writing may be less influenced by their subject knowledge than by their organizational skills.

Composing

The objective of the composing activity is to create text, which by definition is a linear sequence of ideas expressed within the constraints of certain grammatical rules. This text represents the ideas and the structure from the generating and organizing activities.

Generating and organizing do not produce text which directly satisfies the writer's purpose. Instead, they produce ideas which the writer must translate into text under the direction of

a) a general writing plan from LTM,

b) ideas on structure from LTM and notes, and

c) specific pieces of information obtained from LTM and notes.

Revising

Using this activity, the writer changes the text composed in the previous activity to conform to goals set in the original plan. Perception of dissonance between intention and execution serves as a cue for possible revision of the offending text. In addition, revision may involve better expressions of statements that were acceptable in the original text (e.g., to make them clearer, more succinct or more descriptive). Revision may also occur at the planning level if a part of the plan is judged to be inappropriate in some way.

Relationships Among Activities

Although this framework consists of four activities (generating, organizing, composing, and revising), it is important to remember that writing is not a staged sequential process. A writer need not finish generating ideas before starting to organize them or finish organizing before starting to compose. Instead, the process is both iterative and recursive. A creative writer will likely be generating new ideas throughout the writing process. Writers may stop to compose notes at any point. Revision can be applied to any of the intermediate representations of the final text including rough notes.

It should be noted that the four activities do not ordinarily receive equal amounts of a writer's attention: "... professional writers probably spend 85 percent of their time prewriting (generating and organizing), one percent writing (composing), and 14 percent rewriting (revising)" (Murray, 1972, in Marcus and Blau, 1983) (parentheses added).

Writing Plans

Since the different activities which make up the writing process are used interactively in flexible combinations, the writer is continually faced with decisions about the writing activity to engage in next. Although the writer would like to be addressing the overall goal of the writing task, each of the activities constrains the writer to some subgoal. Viewed from this perspective, the writing process consists of continually juggling these constraints in an attempt to satisfy the overall goal. This is a source of cognitive strain for the writer.

To be effective, writers must develop a strategy to reduce this cognitive strain and still manage the constraints. "One of the most effective strategies for reducing cognitive strain without ignoring interacting constraints is planning" (Flower and Hayes, 1980). Plans interact with generating and organizing activities to form models with a certain level of abstraction. They allow the writer to a) define manageable subproblems and b) test and discard alternatives. Effective plans must be detailed enough to test and work from. They must also be sufficiently 'cheap' (in terms of the effort required) to allow the writer to discard plans which fail to prove useful.

Expert vs. Novice Writers

Within the context of the revision process, Hayes and Flower (1986) make a distinction between novice writers and expert writers. Novices view revision as a sentence-level activity intended to improve the wording of small, local sections of text. Experts focus primarily on the form and structure of the text and secondarily on concern about the nature of the intended audience. Experts are more likely to change meaning through revision.

Only a small portion of the population of literate children or adults can be considered expert writers. "The structure of the writing process is much simpler for the relative novice... The relatively more expert writers, on the other hand, construct much more complex representations of the writing task, plan and revise plans, check results against goals, and consider a variety of kinds of information" (Bereiter and Scardamalia 1986).

Novices' revisions of text tend to be superficial and cosmetic, but novices can acquire sufficient superficial skill to produce well-polished phrasing which meets the requirements of most school writing assignments. Consequently, many young writers receive frequent reinforcement for practicing novice writing behaviors. There is often little incentive for either teachers or learners to exercise the effort or commitment required for the deeper understanding of the writing process that is characteristic of expert writers.

Related Issues

Our emphasis here is on the use of word processors as writing tools; however, computers may also aid the writing process in other ways. The following comments apply to the broadest possible sense of using the computer as a writing tool:

1. Computers may be used to provide "conversational" support for writing. Participating in a conversation about a topic has an advantage over writing about the same topic. Participants in the conversation provide probes which help each other generate information and ideas. Writing is usually an individual activity so the writer is solely responsible for generating information. Computer-based writing has the potential to turn writing into a dialogue and provide at least some of the prompts upon which fluent conversation depends.
2. Superior writing processes are characterized by considerably more time spent generating and organizing. If it were therefore deemed desirable to require students to focus on generating and organizing, it would be possible to use computer software to constrain the writer to these activities during the initial writing stages.

3. Some writing activities operate at a meta-structure level in which writers add comments and opinions that reflect their attitudes towards both the content and the structure of the content. If the writer can actually see an explicit representation of the structure of the text produced, the addition of this meta-structural information will be facilitated. Ideally, the writer should also be able to annotate this representation. Changes made to the representation of the structure should update the actual text and changes to the text should be dynamically reflected in representations of the structure. Computer assistance could be used to provide such a flexible representation of the structure of a text.

4. As early as 1980, Collins and Gentner postulated the development of a "Writing Land": a computerized writing environment designed to implement many of the aspects of their model. This environment would provide tools to facilitate the mechanical process of text composition and to reduce and focus constraints. It would also contain an artificially intelligent writing assistant to provide advice on the various aspects of the writing process.

5. To date, computer support for the writing process has mainly centered around composing and small scale revising activities. The ability of word processors to facilitate major structural revision has been used to a lesser extent. Some support for organizing has been provided by outliners. At present computers provide greatest support to the writing activities which predominate in novice writing and use of word processors with these limited capabilities may be contributing to the perpetuation of novice writing behavior. Fortunately, this is

changing. New computer writing environments provide support for the full range of writing activities. The use of these more sophisticated writing tools, along with a change in pedagogical emphasis, may encourage children to become expert writers instead of polished novice writers.

6. As part of the prewriting process, organizing is necessary to satisfy two objectives. First, the writer must bring together scattered ideas and facts in a manner which makes sense. Organizing helps the writer understand the relationships between the individual items. A writer should look for a variety of organizations to provide different perspectives on the material. Second, though not necessarily later, the writer must impose a linear structure on the information so it can be represented in a linear document. Again, the writer will likely try several different organizations with the objective of finding the one which is the most appropriate for the audience. Two advanced writing environments, NoteCards (Trigg and Irish, 1987) and Writing Environment (Smith, Weiss and Ferguson, 1987), support easy organization and reorganization of information and provide the writer with meaningful representations of each alternate structure. These environments can allow the writer to manipulate the information associated with each of these activities and reflect the results throughout the system.

7. Constraints imposed by the writing process actually interfere with that process. Effective writing results when the writer can reduce the cognitive strain introduced by these constraints. A suitably designed writing environment may reduce this strain by providing general support for all activities associated with the writing process.

Assessment of Writing

Examination of empirical research in any area requires an understanding of the measurement procedures used in data collection. Measurement issues are particularly problematic in investigations of complex cognitive behaviours like writing. In this section we will a) briefly review the major issues in the assessment of writing and b) examine assessment methods used in research in word processing research and c) present results of investigations of the effects of using word processors as writing tools. We intend the review of assessment issues to provide the reader with an appropriate context for understanding the implications and the limitations of the body of research.

Holistic vs. Analytic Methods

Much of the research into the effects of using a word processor on writing quality uses the holistic method of assessing writing quality. There seems to have been little consideration of whether this is the most appropriate measure for this type of research, but Moore and Kennedy (1971) pointed out two disadvantages of using standardized tests to assess writing ability: a) few standardized tests have been updated to reflect the changes in English curricula that have taken place since 1960 (still true in 1988) and b) the questions on such tests often primarily reflect the test designers' need for the questions to be easily scorable. Consequently, each multiple choice item is designed to measure a single skill, but Moore and Kennedy argued that "...such fragmentation is highly artificial. In writing his own stories and letters, the pupil must put everything together; he cannot afford the luxury of being concerned solely with isolated skills."

White (1985) supported this view: "Inappropriate testing has been destructive to the teaching of writing for the last two generations." White described and defended the use of an holistic approach to scoring students' writing. Holistic scoring involves several raters assessing a single written product. Unlike the information obtained from multiple-choice tests, holistic scoring results in an evaluation of a student's complete written product which should reflect the full range of generating, organizing, composing and revising activities.

As with any measurement, reliability is a concern with holistic marking. White acknowledged that reliability is a problem for "the general impression scoring that Diederich tested," but he noted that the "primary trait scoring" of the National Assessment of Educational Progress and the holistic scoring done by the Educational Testing Service have high inter-rater reliability as a result of systematic scoring procedures.

Wilkinson, Barnsley, Hanna and Swan (1980) also endorsed holistic scoring, claiming that the tradition of analytic marking of national exams for school children in Britain covered the same areas that multiple-choice tests easily assess. They believe such procedures overemphasize vocabulary, grammar, punctuation, proper sentence structure, spelling and handwriting and that they fail to consider such important aspects of writing as purpose and sense of audience. They cite Wiseman (1949) and Britton (1963) as having demonstrated that analytical marking and holistic or impression marking do not differ in reliability. Wiseman also reported that using four independent markers required no more time or effort than is required by one analytical marking.

White (1985) also examined the relationship between students' scores on multiple choice tests of grammatical knowledge and their scores on writing samples. The correlations he obtained indicated that students' test scores predict approximately 25% of the variation in the holistic marks given on the writing samples. In other words, the two methods measure different skills.

Disadvantages of holistic scoring procedures are a) the marks produced are percentiles in a particular norm group (e.g., for one year's testing) and b) normative cut-off scores are used (and they change each year) (White, 1985). In addition, White argued that the use of a single, undifferentiated mark, without any explanation of the reasons for low marks, makes it impossible to use the scores to make meaningful educational diagnoses. Analytic marking of various sub-skills is an obvious alternative, but White maintained that we lack agreement about what these sub-skills are. Since analytic scoring takes longer, it "...solves neither the reliability nor the cost problem". Despite the cost of scorers, White (1985) claimed that the holistic approach is more economical than multiple choice tests given the "hidden costs" of test development for multiple choice tests.

White's claims notwithstanding, the issues of relative economy and reliability for holistic vs multiple choice tests are not resolved. For example, once developed, multiple choice tests may be used repeatedly, are easily revised, and may be computer scored. In addition, well-established procedures for assessing other forms of test reliability (e.g., internal consistency, equivalence and stability) have no parallels in holistic methodology.

Some developers of multiple-choice tests are now focusing on indirect tests of isolated abilities (e.g., Benton and Kiewra, 1986). It is not clear whether such an investment is warranted. There is a great deal of work to be done in establishing that the tasks performed on these tests are valid measures of agreed-upon writing sub-skills.

Future developments aside, it appears that, at this time, the reliability of holistic scoring methods and their obvious face validity make them the preferred evaluation procedure for many contemporary language arts specialists.

The Assessment of Writing Quality in Word Processing Research

Despite the virtues of holistic approaches to assessing writing quality, we might reasonably expect that studies using this measure of quality would not reveal differences between compositions written with pen and paper and those written with a word processor. Too many other variables enter the writing process. Even if the amount of time, effort, mental planning and other composing strategies students use differ with the medium used (e.g., Selfe, 1985), it is unlikely that such procedural differences would be reflected in any overall assessment of the quality of the final written product. Since subjects in word processing experiments are usually allowed to take as long as they need to write their compositions (Hawisher, 1986; Kurth, 1987) we should expect that they will work until they have reached the quality of writing that they are accustomed to producing regardless of the writing tool they use. Thus there would be no significant benefits found for word processing. In the one study that controlled writing time (Etchison, 1985), considerable differences in quality and quantity of writing in favor of those who used word processors (details provided in a

later section). It is possible, therefore, that the benefits to be derived from the use of word processors can be found in the possibility of writing compositions of equal quality in less time.

It is also possible that the benefits of using a word processor will only be seen with measures that take a more analytic approach to the assessment of writing. For example, in a longitudinal study of 211 elementary and secondary school children, Loban (1976) developed and validated a variety of measures based on carefully defined word counts (for instance, contractions were counted as two words). His analysts were trained to have high reliability in dividing texts into "communication units," which he defined both semantically and structurally. Semantically, communication units are groups of words that cannot be "further divided without the loss of their essential meaning." Since "essential meaning" is difficult to operationally define, Loban also used a structural definition of a communication unit -- an independent clause with its modifiers, also known as T-units (Hunt,1977).

Loban found that the average number of words per communication unit in children's writing increased steadily from grade 4 to grade 12. At each grade level, students who had been independently rated high in language proficiency wrote longer communication units than did subjects who were rated low in proficiency. The number of words per communication unit was used instead of overall length because the former is a more refined measure which seeks to tap the richness of the description of each complete thought. The age trends in Loban's data suggest that it could be used as a measure of writing maturity. He also developed an "elaboration index" to measure the number of different strategies students used to lengthen their communication

units. Results obtained with this index closely paralleled the simpler measure, length of communication unit, suggesting that the latter may be a productive measure of writing quality in research on the effects of using word processors to write.

Evaluation of Revision

Another manner of achieving specificity in writing assessment procedures is to investigate the effects of word processor use on various stages of the writing process. To date, such efforts seem to be limited to investigating revision. In a synthesis and elaboration of efforts to develop an evaluation scheme for assessing the length of revisions, Bridwell (1981) proposed classification of revisions into the following seven levels: surface, lexical, phrase, clause, sentence, multi-sentence, and text.

Faigley and Witte (1984) developed an evaluation tool that prompts an evaluator to assess instances of revision, such as additions and deletions, and determine whether they affect the structure and meaning of a text at a micro or macro level ("meaning change" or "surface change"). They stressed that the evaluation of revision must be made with respect to the situational variables of the writing task: the author's reason for composing, the format of the composition, the writer's knowledge of the subject area and the audience, the degree of formality required for the writing, and the length and complexity of the task. The same writer may demonstrate different revision behaviours and skills when the situational variables change.

Scardamalia and Bereiter (1986) examined the relationship between writing and cognitive processes and cautioned against over interpreting changes in text. They explained that instruction can all too easily help subjects to produce longer pieces of writing or to revise individual texts

without resulting in any cognitive change. They recommended that evaluators carefully note and assess a writer's surface behaviours because they are windows on his cognitive activity and strategies.

The Effects of Word Processing on the Quality of Writing

Anecdotal accounts of the benefits of word processing are abundant, but this literature is by no means unanimous. For example, Hermann (1987) found that learning the mechanics of using a word processor interferes with the writing process. Yet Branan (1984), Willer (1984) and Ho Chung Qui (1986) reported increased amounts of creative writing in learning disabled children who had been taught word processing.

In light of this diversity, it is not surprising that empirical research regarding the effect of word processing on the quality of writing is also inconclusive. The following summary attempts to provide a synthesis of research that has examined the effects of word processing on the quality of writing.

Studies of composition length

Kurth (1987) found no significant difference between control and treatment groups in length of compositions produced. Her subjects were high school students who were participating in an experimental writing course as a voluntary extra-curricular activity. Some of these subjects took their writing home to work on. It seems likely that these subjects would continue to re-think and revise their work until they were satisfied -- regardless of the amount of extra time it would take to write by hand. With writing time controlled, however, Etchison (1985) found that students using word processors made greater increases in length of composition from pre to post instruction. His students had two days to plan their compositions, one hour to write, and

then two days later were given a one hour revising session. Willinsky (in press) has found that education students whose normal course assignments were prepared on word processors wrote approximately 20% longer papers than those using typewriters or pen and paper.

Studies of holistic quality

Hawisher (1986) and Cross and Curey (1984) found that overall quality ratings for essays produced with word processing were similar to those for essays produced with pen or typewriter. Willinsky (in press), using grades obtained on assignments for a variety of education courses, found no significant difference in marks earned by students who word processed their assignments, those who typed them, or those who wrote in long hand. Etchison (1985), on the other hand, found that gain in holistic quality with use of the word processor was five times that obtained by use of pen and paper. It is important to note that Etchison took pains to control many other factors that might effect the quality of the final product (e.g., time allotted to the writing task, writing environment, etc.) It is quite likely that with his timed writing sessions, Etchison has provided an empirical measure of how much more quickly students can compose and revise on a word processor after a semester of use.

Analytic studies

Etchison (1985) also measured changes in syntactic variables such as free modification, number of clauses, average number of words per clause, and type of embedding, but found no significant differences in these areas between students who used word processing and those who did not.

Other variables

Suggestions of other factors that can influence the quality of writing when using a word processor include context of the assignment (Hermann, 1987), conferencing (Etchison, 1985), opportunity to develop new skills in areas where concepts are new (Coombs, 1985), and classroom demonstrations of the technology as a means to an end (Cross and Curey, 1984). Cross and Curey also stated that the overall effects of word processing on writing vary with the writer and with general factors related to the teacher and the class.

The research we have encountered, though limited, indicates that the quality of documents prepared with word processors is at least as high as that obtained with other writing tools and that other variables are more important determinants of writing quality. Macarthur (1988) cautions that improvement should be credited to instruction and skill development rather than to the writing tool. Other authors (Hooper, 1987; Hult, 1986; Opack, 1986; and Kurth, 1987) suggest that writing instruction must be given concurrently with the teaching of word processing skills if better quality writing is expected to result.

The Effects of Word Processing on Revisions

Several studies have examined differences in the ways writers approach revision when using a word processor as compared to other writing tools. Some have focused on the number of revisions made (e.g., Hawisher, 1986; Cross and Curey, 1984) while others have focused on the kinds of revisions made (Willinsky, in press; Kurth, 1987; Hawisher, 1986). Macarthur (1988) and Hult (1986) compared word processing revisions between experienced and inexperienced writers.

In a critical review of the literature, Hooper (1987) concluded that word processors ease the revision process (Freeman, 1987; Nash, 1985), that most revisions are purely cosmetic (Womble, 1984) and that fewer substantial revisions are made by students using word processors (Harris, 1985). Students in Willinsky's (in press) study also indicated that their most frequent revising activities were minor changes -- spelling and grammar corrections or the addition, deletion, replacement, or re-ordering of words. In this study, students using word processors reported more revisions in all these categories than did students using typewriters or pens. They also reported more additions of sentences and of paragraphs -- more significant changes than those found in most earlier studies. This finding is consistent, however, with Hunter's (1983) observation that, over a series of five drafts, students made as many additions, deletions and changes to paragraphs as they did to words.

Hawisher (1986) examined the effects of word processing on the revision strategies of college students and concluded that extensive revision was not positively correlated with quality ratings and that students writing with a computer did not make different <u>kinds</u> of revisions than did those using pen and typewriter (using Faigley and Witte's, 1984, classification of revision into "surface change" and "meaning change.") The revisions studied here were those noted as differences between the first and second or between the second and third drafts; it is not known whether the conclusions would also apply to revisions made in the process of composing. In a later study, Hawisher (1987) found no qualitative difference in the revisions made by those who used a computer compared to those who wrote with pen. She suggested that the initial draft, "the point of utterance" has a greater effect than revisions on the

ultimate quality of the product. However, it may well be that this is simply a reflection of the minimal revision which other researchers (see above) have found to be the norm.

As with quality of writing, more than the word processor is needed to make revision effective. Students need to be taught effective revision strategies including the value of such functions as moving and deleting blocks of text (Hult, 1986).

The cognitive demands of writing are too great for a young person to monitor composition with the efficiency that skilled adults have developed. To ease the cognitive demands of the writing process, Woodruff, Bereiter and Scardamalia (1982) provided elementary school children with a word processor that could provide on-line support to help them carry out the composing process. The students could activate a hierarchy of menus which provided writing aids. Although the students frequently summoned this assistance and believed that it improved their writing, the researchers found that it made no significant difference in either the quantity or the quality of the students' compositions, a finding consistent with Daiute's (1986) report that the availability of on-board writing aids did not help eighth grade students to improve the quality of their writing.

Kurth (1987) also reported that use of a computer did not improve the quality or quantity of junior high school students' writing. However, when her subjects used a spell checker they had fewer spelling errors than when they used pencil and paper. The high visibility of text on a screen fostered more conversation about writing among students in a group that used a word processor than occurred among those in a group that wrote with pen and paper. She concluded that the quality of students' writing is affected more

by good instruction than by the writing tool.

Hult (1986) found the revision strategies of inexperienced writers centered around the word as a unit thus resulting in surface or editorial revisions. Experienced writers tended to see the composition as a complete activity; therefore, they made more changes to style and content. Macarthur (1988) found that, in general, experienced writers make more revisions than inexperienced writers when both groups are using word processors. He also cautioned that easing the physical requirements of revision will not result in better compositions unless students know how to evaluate and correct their writing.

Likewise, Lutz (1987) observed that the writing behaviour of experienced and professional writers was different when they were word processing than when they were using pen and paper. The computer's small window on a document encourages local editing but may limit the writer's perspective on the document as a whole and thereby discourage deep revision of the text. Revision was more effective when done with pencil and paper or when done on hard copy.

Affective Aspects

Almost every report on word processing and the writing process makes some mention of affective change, but few go beyond reporting the casual observations of the investigator and/or teachers. Kurth (1987) and Coombs (1985) observed increases in self confidence as a writer and one teacher (Ho Chung Qui, 1986) believed this change carried over into other areas of the children's behaviour. The most frequently observed effects are increased motivation and enthusiasm for writing (Johnson, 1987, Hawisher, 1986,

Coombs, 1985, Feldman, 1983), desire to write more precisely (Daiute,1983, Newman, 1987) and greater willingness to revise (Kurth,1987, Schwartz, 1982). Branan (1984), Teichman and Poris (1986) and Feldman (1983) reported that students using word processors showed decreased writing anxiety. As an indication of motivation to write, Bruce (1985), Wheeler (1985) and Macarthur (1988) observed a greater sense of audience in students using a word processor to write. The overall message is that word processing makes writing more enjoyable (or at least less unpleasant). However, even in this area, the literature is not completely consistent: Fitch (in Hooper, 1986) reported no significant change in attitude when students used word processors to write.

Keyboarding

Since keyboards are the primary means by which students communicate with computers, inadequate typing skills may be regarded as lack of communication skills for those who use microcomputers. Many teachers consider poor keyboarding skills to be an impediment which leads to ineffective, inefficient, and frustrating experiences for the students.

If computers are to be integrated into the school curriculum, the question is not, "Should students learn to use the keyboard?" Rather, the kind of questions that require attention are:

a. How ought children learn to use the keyboard?

b. When should keyboarding instruction begin?

c. What levels of achievement can we expect from the students?

d. What are students' attitudes toward keyboarding?

e. Who should teach it?

and so forth.

These are questions commonly asked by teachers and administrators; they deserve informed responses.

How ought children learn to use the keyboard?

Responses to the remaining questions reflect published research and authoritative opinion about the place of keyboarding skills in contemporary schooling. Of necessity, perhaps, this published work presents a limited perspective on the role of keyboarding instruction. To begin with, it seems clear that all of the writers accept that instruction (some formalized presentation of information in a predetermined organization) is synonymous

with learning (or at least with teaching). This position is at odds with the contemporary emphasis on construction of individual meaning as the basis of meaningful learning. Constructivist views tend to emphasize the learner's need for free exploration and discovery in an environment conducive to the creation of personally meaningful organizations of knowledge. Since constructivist thinking is particularly dominant among language arts specialists, the stage has been set for a major confrontation between teachers of writing and teachers of keyboarding. The former, especially at the elementary school level, favour allowing children to use the keyboard as they see fit and to focus the children's attention on the writing process. The latter, usually secondary school business education teachers, perceive such a procedure as wasteful of time and resources and likely to induce frustration among learners (this may be true of older children and adults, but it does not seem to be the case with young children). Moreover, keyboarding instructors fear that children will learn "bad habits" ("hunt and peck" typing) which will be difficult to extinguish and which will interfere with the learning of touch typing skills. Despite the persistence of this concern among business education teachers, we were unable to locate a single study comparing the learning curves for novices with "bad habits" to those with no previous experience. This is not a trivial question since the attention of keyboarding teachers might well focus selectively on those students who have difficulty. If some students who entered instruction with "bad habits" do as well or better than other students, the presence of their "bad habits" might never be noticed.

Research could easily be designed to answer the "bad habits" question, but the broader question of instructional method is inherently a value

question even though research results might help individuals to form their own opinions. It is entirely possible that some middle ground exists which in young children are encouraged to "experience" the keyboard much as they experience language in their daily environment while older students are given the opportunity to learn "proper" fingering and touch typing skills. (Ideally, this decision would be made by individual students as they perceive the general advantages of, and their own need for, touch typing.) Such a development would be consistent with much of the literature to follow in this section; however, in responding to the remaining questions, we will adopt a more-or-less instruction-oriented viewpoint because

a.) it better reflects the literature

b.) physical skills (like keyboarding) lend themselves to instructional or training methods, and

c.) a relatively short period of instruction is suggested by most writers.

<u>When should keyboarding instruction begin?</u>

The literature, though scant, indicates that keyboarding can be taught effectively at any grade level. However, the need for it and the level of achievement that can be expected from students decrease with grade level due to the fact that keyboarding, although viewed mainly as a gross and fine motor skill, is directly affected by the cognitive, affective, and psychomotor development of the learner, which varies greatly from child to child, especially in the earlier years.

Cowles and Robinson (1983) demonstrated that children as young as five years of age were able to learn keyboarding and found that success in keyboarding is correlated with reading ability as well as with gross and fine

motor development. Ball (1985) saw keyboarding instruction for children in grades K-3 as highly controversial since there is little evidence to suggest that these children have the prerequisite reading ability and psychomotor development. Moreover, software developed for this age group commonly requires only single keystrokes or simple word entries and does not require the skills of two-handed typing.

> The physical span of (a young child's) fingers is not yet sufficient to cover the required keys in the "home" position, and yet, one of the objectives to be met in touch typing programs is correct finger placement in "home" position. In addition to physical dexterity, learning to type involves several other independent skills, including letter recognition, letter location on the keyboard, discrimination between lower and upper case letters, and the skills needed to combine letters into words. If young students are still struggling with the recognition and order of letters in the alphabet, it seems premature to worry the student with where the "a" is on the keyboard and which finger should be used to type the "a" (pp. 4-5).

Warwood, Hartman, Hauwiller and Taylor (1985) also found that current software for grades K-3 required only single keystrokes or single word responses, but software for grades 4-6 required students to enter complete sentences which demands a higher level of typing ability. They also replicated Cowles and Robinson's (1983) findings that reading levels are correlated positively with pretest typing scores.

Warwood et al. (1985) questioned whether children below grade four can successfully learn to use a keyboard and whether there is need for them to do so. By contrast, Jackson and Berg (1986) claim that research indicates children are developmentally ready for keyboarding instruction by grade three.

Clearly, there is not a consensus about the instruction of touch typing in grades K-3. Whether or not very young children possess the prerequisite

cognitive and psychomotor skills required of touch typing is questionable. Perhaps more pertinent is the question of whether touch typing is even a required skill within the K-3 curriculum and whether possessing such a skill will reduce frustration levels, enhance interaction with the computer, and be a skill which does not extinguish due to lack of sustained use.

Many researchers maintain that it is important to prevent the development of "hunt and peck" typing habits (e.g., Rauch and Yanke, (1982); Britten, 1988; Stewart and Jones, 1983). Stewart and Jones (1983) captured this group's sentiment about young children's keyboarding:

> In typewriting classes they will have to unlearn bad techniques and will be expected to develop suitable habits for the level of skill demanded by the business office. However, any typewriting instructor who has experienced the challenge of retraining a typist under such conditions will readily admit that the task is difficult if not impossible (p. 11).

Despite the controversy among researchers and concern among teachers about when keyboarding should be taught, there remain some consistencies that can provide guidance to those faced with decisions about program implementation. For example, many researchers have found the teaching of keyboarding feasible from the fourth grade level. However, such a program must be justifiable on the grounds that daily practice of the skills and a continuous need for them is present, implying that word processing would be an activity integrated into various subject areas. The consequences of proceeding without such justification can be seen in Warwood et al.'s (1985) finding that 40 days after termination of the keyboarding instruction period the students had dropped back to pre-instruction performance levels. Balajthy (1987) and Schellinger (1987) also emphasized the importance of continued practice if keyboarding skills are to be maintained.

In light of the vigorous assertion by business educators that proper typing technique must be used at all times, and in light of the findings of rather rapid extinction of proper keyboarding technique without continuous practice, it is interesting to note that no researcher has asked whether "hunt and peck typing" is as easily extinguished in similar circumstances.

Rather than attempt to define the age at which keyboarding instruction should begin, Byfield and LaBarre (1985) suggested that students should develop keyboarding skills just prior to the time they will apply them and that it is inappropriate to make an arbitrary decision or recommendation about the best grade level for development of keyboarding skills. Likewise, Williams (1988) suggested, "Teachers and appropriate administrators must work together to devise an articulated plan that begins at the elementary level and continues through high school, with the learning experiences becoming more advanced as time goes on" (p. 28).

In conclusion, then, the literature seems to suggest that keyboarding instruction should begin at grade four or later provided that students will be given ample reason and opportunity to use those skills frequently in the remainder of their school program.

What levels of keyboarding achievement can be expected?

Wetzel (1985) noted that third, fourth, and fifth grade students without typing instruction transferred text from paper to screen at the rate of 2.5 gross words per minute -- about one keystroke every five seconds. Loud (in Gerlach, 1987) found that students may take up to an hour to type a page or two of text that could be done more quickly by hand. Kane (in Gerlach, 1987) observed that even those students who had had instruction in touch typing were not proficient typists.

It is clear that the objectives of any program will determine to a large extent the program length and daily commitments to it. The objectives, of course, will vary according to the grade of the child and the amount of integration of computers into the school curriculum. There is very little agreement in the literature as to what constitutes an ideal instructional program in keyboarding. Common beliefs are that typing speed and accuracy must increase relative to the amount of information that must be entered by the student. It has been suggested that early elementary grade children should become adept at merely locating keys on the keyboard to facilitate the minimal data entry required of them (Ball, 1985; Jackson, 1985), but that older children require proper keyboarding to reduce frustration and increase efficiency with the kinds of tasks they work on. Common suggestions for program length and daily sessions are from twenty to thirty hours for an introductory course with daily practice sessions from twenty minutes to fifty minutes depending upon the grade level. Headley (1983) was successful in teaching grade five students using a commercial software package in thirty minute sessions with a total program length of twenty hours. The Minnesota Curriculum Services Center suggests a twenty to thirty hour program consisting of classes of thirty to fifty minutes duration with reduced class length for lower grades.

Byfield and LaBarre (1985) taught upper elementary students in twenty-five hours over a six week period. They found that increased practice resulted in increased speed and accuracy which enabled students to concentrate on the writing task. A similar observation was made by Wetzel (1985). He reported that students typing as slowly as seven to ten words per minute did not scan the keyboard, did not become frustrated with keyboard input, and did not lose

their place on screen or paper. He therefore suggested that this might be a reasonable achievement level for adequate use of the keyboard requiring a significant amount of text entry.

Reported levels of speed achievement vary considerably. Ray (in Warwood et al., 1985) reported that fifth and sixth grade students typed an average of 40 words per minute after one year of one hour per day of instruction. Kercher (1984) reported grade five students typed an average of 22 words per minute after nine weeks at 45 minutes per day.

Success in this area is not limited to the average student. Saka (1987) reported that in his study of various developmentally handicapped young adults, successful keyboarding skills were achieved. After six months at two hours per day, five days per week, typing speed increased from a beginning mean of 10 words per minute with 74% accuracy to 23 words per minute with 88% accuracy. He also found that the individuals gained confidence with results.

Success in keyboarding programs, especially at the younger or introductory levels, must not be based on typing speed. Most typing instructors agree that technique is the first goal to be achieved with speed and accuracy progressing with practice. Warwood et al. (1985) found in their experiment that rushing students resulted in failure to achieve objectives and student discouragement.

The implications of this body of research were neatly synthesized by Wetzel:

> If frequent and repeated use of the keyboard is required to achieve program goals, students must be proficient at the keyboard. Keyboarding technique should support, not hinder, achievement of problem solving or composing. But establishing keyboarding skills takes time. Is keyboarding instruction worth the time in the elementary school? The answer is found by balancing classroom time required to achieve keyboarding skills against the advantages

> gained by rapid keyboard entry of data now and later. (1985, p. 18).

What are students' attitudes toward keyboarding?

There is, unfortunately, very little empirical evidence in this area. Most of the available information comes from observations of researchers. Gerlach (1987) found that fourth graders who learned keyboarding to use a word processor did not display a more positive attitude than other students. However, none of students who used a word processor indicated a dislike for typing and most students indicated that they enjoyed using the word processor. These results are consistent with those of Levin, Riel, Rowe & Boruta (in Gerlach, 1987), Palmer, Dowd & James, (1984), and Papert, (1980). Wetzel (1985) noted that students who lack keyboarding skills exhibit great frustration having to look back and forth from handwritten notes to the keyboard, and finally to the screen, constantly losing their place and having to verify letter location on the keyboard. Gottschalk (in Brady, 1984) noted that students who write faster by hand tend to dislike typing. Daiute et al. (in Wetzel, 1985) reported that students who are better at typing are also more enthusiastic about using the word processor for writing. Warwood et al. (1985) stated, "The faster students can type, the quicker they can enter data into their computers and the less frustrated they get in the process" (p. 17).

Warwood et al. (1985) stated that students prefer the use of computers over typewriters when learning keyboarding because the computers provide immediate feedback, because mistakes on computers are less embarassing, and because assessment by the computer is less personal and subjective than teacher evaluation.

While the research to date suggests that students enjoy using keyboards

and word processors, the broad general nature of these studies leaves many questions unanswered. For example, would Wetzel's (1985) students have been happier if they had been composing at the machine? Do the sex differences observed in attitudes toward computing (e.g., Collis, 1988) also appear in attitudes toward keyboarding? What age differences exist? Does the learning context (e.g., keyboarding class vs. English class) affect attitudes? What differences in attitude apply to the Dvorack keyboard? And so on. We can proceeed to teach keyboarding skills knowing that, in general, students enjoy using keyboards, but as more students use keyboards more often answers to questions like those above will be necessary to adapt our teaching to different students and differing circumstances.

Who should teach keyboarding?

Rauch and Yanke (1982) conducted a survey which asked who should teach keyboarding at the elementary level. Intermediate teachers favored a high school business education teacher in the lead position while primary teachers favored the elementary classroom teacher with assistance provided by a business education teacher. Business education teachers claim that they alone are capable of teaching the complex task of keyboarding since they have been trained in the developmental and psychomotor aspects of typing and understand the intrinsic and extrinsic motivational factors necessary to an effective instructional program (Kisner, 1984; Dickey-Olsen in Schmidt, 1983; Headley, 1983). Williams (1986) reported that after three weeks of learning, elementary teachers were already able to competently teach keyboarding to elementary age students and felt confident doing so. Teachers who were able to type required only one day to learn how to instruct their students.

Recent research emphasizes the advantages to both teacher and student of

using typing tutorial software. For the student, these include immediate feedback, motivational graphics, individualized and interactive instruction, the unlimited patience and tolerance of the computer, and a lack of personal evaluation by the teacher. For the teacher, computer software removes the necessity of tedious and time consuming hand-marking of typing exercises, thus significantly increasing the teacher's availability for monitoring student technique and interacting personally with students. The most often cited software package in the research literature is Microtype's The Wonderful World of PAWS for the Apple II family of computers.

How many computers are required to teach keyboarding?

In 1981, Wallace stated, "Economically it is feasible to equip and maintain the modern keyboarding classroom with terminals or microcomputers at a cost equal to or less than equipping it with conventional typewriters" (p. 27). The research literature does not address issues in the design of instructional environments for keyboarding; such information may exist in other sources. Mention is made, nevertheless, that computer stations must meet the physical requirements of the user which will be substantially smaller for elementary than for secondary students.

Warwood et al. (1985) noted that the consensus in the research literature indicates there should be one microcomputer in each elementary classroom along with a fully equipped lab and a full-time instructor in every building.

Learning to keyboard requires a one-to-one, person-to-machine ratio. Keyboarding is not a skill that can be acquired vicariously. Wetzel (1985) logically points out that, if machine time is limited due to a shortage of hardware, "there is no time -- or need -- to teach keyboarding" (p. 17).

The effect of keyboarding on the written product.

There appears to be no direct effect of keyboarding ability on the final written product. Indirectly, it can be seen that the ability to enter text quickly will allow the student to arrive at the final revision stage sooner. A student who spends an inordinate amount of time laboriously entering text will seemingly have little time to concentrate on the task of composing and may never get around to revising at all. This lack of keyboarding ability may also impact on the amount of time available to other students.

Gerlach (1987) reported that little research is available to indicate the effect of keyboarding skill on composition. She conducted a study to determine whether writing improved when fourth grade students used proper keyboarding with a word processor. Results showed that there was no significant difference in the number of words produced, the number of revisions made or in the type of revisions made at the surface, lexical, phrase, clause, sentence, or multi-sentence levels. Miller (in Gerlach, 1987) and Daiute (1986) report similar findings at the upper elementary level. Gerlach indicated that this could well be the result of a lack of knowledge about revision. Daiute (1986) and Macarthur (1988) indicated that the word processor can only facilitate revision; students must learn revision strategies in order to use this aid. Typing speed is only related to the written product when it is so slow that the student never gets to the revision stage. However, it must be remembered that, even if a student does have time for revision, a lack of knowledge about revision will still result in a final, written product of no better quality.

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